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National Telecommunications and Information Administration

DEPARTMENT OF AGRICULTURE
Rural Utilities Service

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Joint request for information: American Recovery and Reinvestment Act of 2009 Broadband Initiatives:

FEDERAL COMMUNICATIONS COMMISSION
Regarding the Commission's Consultative Role In the Broadband Provisions of the Recovery Act

FCC Docket No: GN 09-04:

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Dynamic Spectrum Management (DSM) Technology Optimizes Broadband Performance for Broadband Initiatives Under the American Recovery and Reinvestment Act of 2009

1 Introduction

The principal goal of the Broadband Initiatives of the American Recovery and Reinvestment Act of 2009 (BIARRA) is to foster universal access to high-quality broadband services in America. These initiatives will stimulate the economy and America's competitiveness by providing (a) direct investment in the deployment of telecommunications infrastructure, (b) access to existing broadband services for communications, education and entertainment, especially for population segments that

have traditionally been underserved, and (c) broadband access networks that enable and stimulate the development and delivery of new advanced services such as IPTV.

While there are several available technologies for the reliable delivery of high-speed broadband services, DSL continues to be the preferred technology worldwide, serving more than more than 65% of all broadband users worldwide and more than 40% of broadband users in America.[1,2] There are many good reasons for the widespread adoption of DSL. DSL allows operators to use existing copper infrastructure to provide dedicated broadband links to each customer.[3] Because of the distinct physical connection to each customer, i.e., the local loop, DSL is ideally suited to unbundling of broadband services. And the economics of DSL, whether served from a central office or from a fiber-fed DSLAM[4], are superior to other wired broadband alternatives. A recent study conducted for Ofcom, the telecommunications regulator in the United Kingdom, estimates that the cost of providing high speed, i.e., in excess of 25 Mbps, fiber-to-the-home services is 5 times (5x) that of providing the same services over DSL.[5] Identifying and exploiting cost-effective, robust, broadband access solutions is critical to achieving BIARRA's objective of universal access.

Judicious selection of access technology alone is not sufficient to achieve BIARRA's objectives, however. The design, deployment and management of the access network must also be judicious. Recent advances in the management and optimization of DSL networks via low-cost software solutions have substantially increased the speed, service quality and achievable loop lengths in DSL networks, while simultaneously reducing operating costs to enable continued affordability of broadband services for the public.

2 ASSIA's Interest In This Proceeding

ASSIA, Inc., is the leading provider of Dynamic Spectrum Management (DSM) solutions to the DSL industry. DSM is a proven, standardized technology for the optimization of

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[1] Point Topic, Ltd., *World Broadband Statistics Report – Q4 2008*, pages 10, 23

[2] DSL penetration is even higher than these statistics would indicate since many customers reported as "fiber optic" customers are in fact served over the last mile or last half-mile, by DSL systems with fiber backhaul.

[3] In cable systems, for example the throughput of a given cable segment is shared by many users.

[4] A DSLAM is a DSL Access Multiplexer, which is a bank of DSL modems operated by the DSL service provider. Each modem in the bank is connected to a copper loop and communicates with a modem at the customer premises. DSLAMs can be located at the central office, or in a neighborhood with backhaul, e.g., via fiber, to the central office.

[5] Broadband Stakeholder Group, *The costs of deploying fibre-based next-generation broadband infrastructure, Ref: 12726-371*, pg. 79

DSL network operations and services.[6,7] ASSIA's DSM solution, DSL Expresse®, is realized in software running on low-cost, off-the-shelf servers in a DSL operator's core network. DSL Expresse can manage any vendor's standards-compliant DSLAM, providing DSL operators with free choice in the selection of DSL access equipment. DSL Expresse® currently manages over 19 million DSL lines in North America and Europe, with other major carrier deployments underway worldwide.

ASSIA was founded in California in 2003 by Dr. John Cioffi, the inventor of modern DSL technology. Previously, Dr. Cioffi founded the company Amati, which created the first DSL chipsets and was eventually sold to Texas Instruments. Dr. Cioffi is an Emeritus Professor at Stanford University, where his research group developed, and continues to advance, DSL and DSM technology. Although DSM is now incorporated in a range of international standards, its genesis was as an American technology and its development continues to be driven by American institutions such as Stanford University, ASSIA and other US-based companies.

3 DSM Supports The Broadband Initiatives of the American Recovery and Reinvestment Act of 2009.

The fundamental benefit of DSM technology is a significant increase in the 'footprint' for DSL services. This means that the service area where customers can enjoy a DSL broadband service at a particular stable line rate is typically increased by 50% or more. With DSM a much larger service area is possible with given capital and operating investments, enabling more users to be served with higher quality of service and at lower costs (and, hence, improved affordability under any rational pricing model). Further, the higher speeds available through DSM increase the numbers of customers that can receive enhanced, bandwidth-intensive services such as high-speed Internet and IPTV. DSM achieves its performance improvements by (a) controlling the interference from other DSL services and from external sources such as AM radio and (b) by compensating for physical impairments on a DSL line through a software system situated in the operator's core network (see the more detailed description below, "How DSM Technology Works").

A DSM software system such as ASSIA's DSL Expresse® continuously monitors each DSL line in an operator's network, and automatically "repairs" the line by reconfiguring its operating parameters if impairments are detected. It also produces diagnostic reports on service quality. As a result, customer trouble reports are significantly reduced, expensive unnecessary technician dispatches ("truck rolls) are avoided, and the

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[6] ATIS-0600007, *Dynamic Spectrum Management Technical Report,* May 2007. Available at https://www.atis.org/docstore/default.aspx.

[7] ITU-T Recommendation G.997.1, *Physical layer management for digital subscriber line (DSL) transceivers*

effectiveness of technician intervention, in those cases where intervention is necessary, is dramatically improved.[8]

These operating improvements lead to economic benefits that generally allow an operator to recoup the cost of deploying DSM technology in less than one year. The end result of applying DSM to DSL is faster, higher quality services to more people at lower prices – all objectives of the American Recovery and Reinvestment Act of 2009.

4 How DSM Technology Works

The *ATIS Dynamic Spectrum Management (DSM) Technical Report*[9] describes how the DSL signal, as transmitted and received by DSL modems, can be used to diagnose and repair service degradation caused by loop impairments and signal interference. The sources of these degradations are electromagnetic signal noise and interference from in-home and surrounding interference sources, crosstalk from other DSL lines in the same cable, and wiring problems both inside the home and in the network outside plant. The production of diagnostic information regarding degradation sources are a basic component of DSM solutions. The most advanced DSM tools go a step further: they automatically reprogram (reprofile) the DSL modems to circumvent interference and many physical plant problems

DSL networks are not static. Network conditions can change on a daily basis as new sources or interference are added to the environment, customer usage patterns change, and modifications to the network are made by service providers. There is thus a need for continuous real-time broadband diagnostics and repair capabilities, as evidenced by an increasing industry interest in tools that could automatically provide those capabilities. Using parameters supported by all standards-compliant DSLAMs, a properly designed DSM system can enhance the performance of any DSL network, including environments with multiple DSLAM vendors' equipment and multiple DSL providers sharing a single copper infrastructure.

5 DSM Results From The Field

The effectiveness of DSM in improving the rate and reach, and hence economics, of DSM has been repeatedly demonstrated in field deployments of ASSIA's DSL Expresse product. Results from several networks are presented below.

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[8] In ASSIA's experience, more than half of all technician interventions in DSL networks are "wasted" in the senses that there was in fact no fault on the line or at the expected location, or that the technician intervention was unsuccessful. Reducing such wasted operating expenditures is key to controlling operating costs and to providing broadband to the largest possible group of citizens.

[9] ATIS-0600007, *Dynamic Spectrum Management Technical Report,* May 2007. Available at https://www.atis.org/docstore/default.aspx

For reference, ASSIA's proprietary implementation of DSM in DSL Expresse is subdivided into three main modules: (1) Performance Optimizer, (2) Upgrade Recommender, and (3) Performance Evaluator. Typically, each line in the network is processed by each module on a daily basis.

- The Performance Optimizer Module automatically stabilizes each DSL line to achieve the highest possible stable line speed, subject to the respective customer's service tier as defined by the operator. Service tier definitions are typically a combination of line rate and QoS criteria such as frame errors and retraining rates. Only those lines that are out of specification with respect to their service tier are adjusted.
- The Upgrade Recommender Module automatically identifies lines that can support a higher service tier. This information can be used by the network operator to offer service upgrades to eligible customers.
- The Performance Evaluator Module uses DSM techniques to continually detect and diagnose service problems such as bad splices, bridged taps, and excessive noise interference, including the type of noise and its likely causes. A Neighborhood Processing Module provides fault localization, identifying whether a fault is situated at the customer premises, in the DSLAM or in a particular binder or geography within the physical plant. The ability to identify problems in binders or in geographic areas that affect multiple customers has proven to be particular valuable: identifying and resolving a problem at the binder level can improve the service of multiple customers, often before the customers themselves are aware of any service degradation.

Figure 1 displays the rate and reach improvements for an ADSL 1/2/2+ DSL network in Europe, for a sample of approximately 700 lines. The horizontal axis is loop length, and the vertical axis is the fraction of lines that can stably support a particular downstream data rate at a particular loop length. Stability here was defined as the ability to provide a broadcast-quality IPTV experience. Curves are provided for 12 Mbps, 15 Mbps and 18 Mbps services, both before and after DSM optimization performed by DSL Expresse.

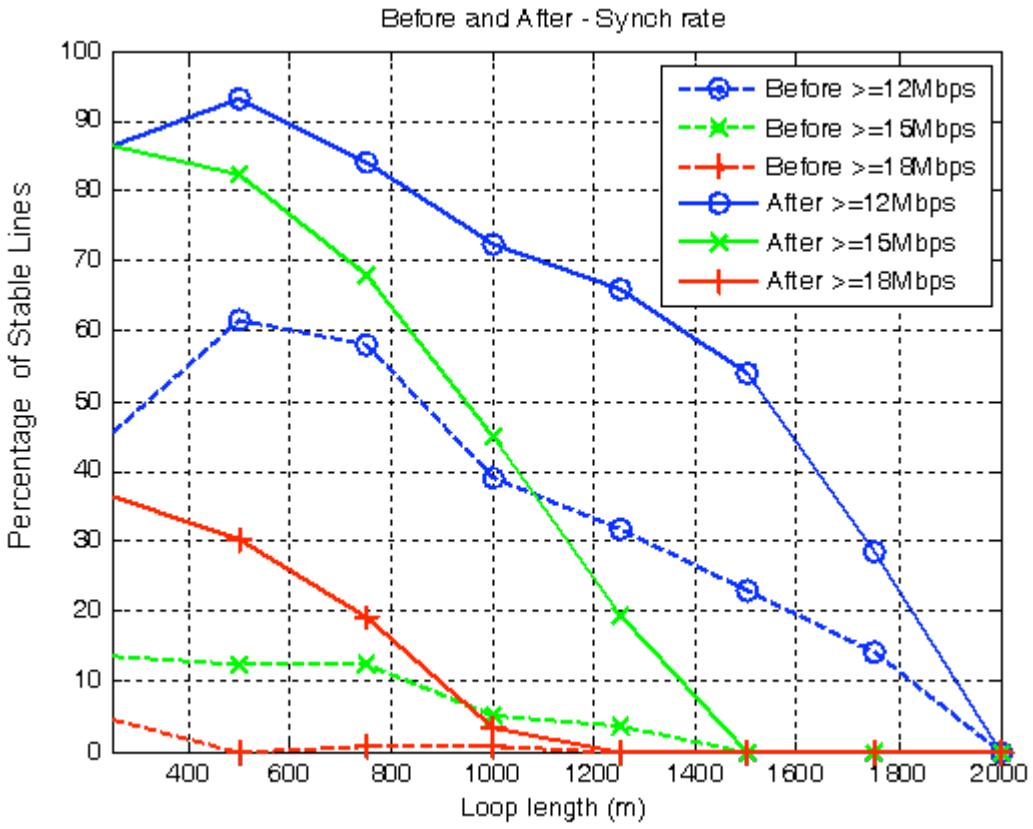

Figure 1: DSM Example #1

Referring to the blue curves (marked with circles), one can see that the loop length at which 60% of the lines could receive 12 Mbps was increased by a factor of approximately 2.5x, from 600 m to 1400 m. Alternatively, at 600 m, the fraction of lines that could support 12 Mbps increased by more than 50%, from 60% of the lines to more than 90%. In the case of the 15 Mbps and 18 Mbps services, few customers could receive these services prior to DSM optimization. Following DSM optimization, a substantial fraction of customers could enjoy these high speed services.

Figure 2 provides an example of 2,500 lines from a different European ADSL 1/2/2+ network with longer loop lengths, perhaps more representative of rural America. Stability in this case was defined to be consistent with a best-effort Internet service. The distance at which 60% of the customers could receive a 2 Mbps service was increased by DSM optimization by DSL Expresse by roughly 66%, from 1500 m to 2500 m. Prior to DSL optimization, there was no loop length at which 50% of the customers could receive a 6 Mbps service. Following optimization, the distance at which 50% of the customers could receive the service was 2500 m.

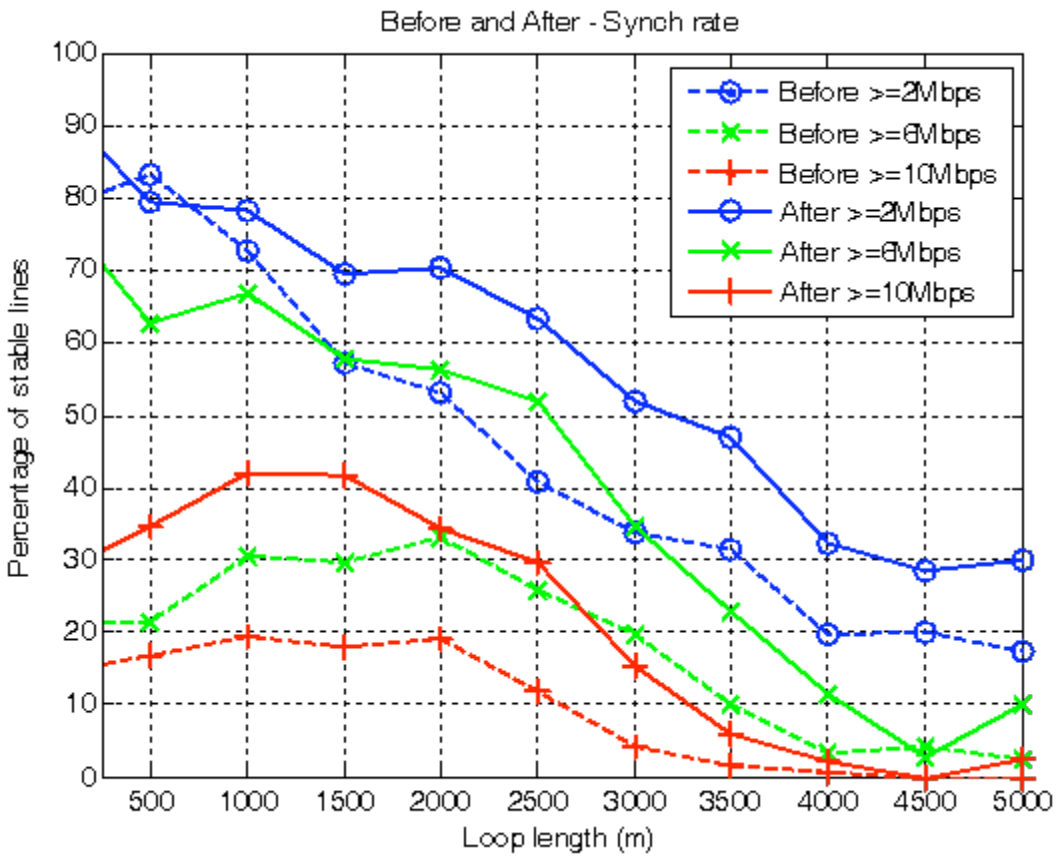

Figure 2: DSM Example #2

The improvements obtained from any particular application of DSM will depend on many factors including equipment selections, service definitions and copper conditions. In all cases, however, significant benefits accrue from the application of DSM.

6 Conclusions

The deployment of universal broadband access will increase America's competitiveness, stimulate the economy and will enable all citizens to enjoy the benefits of 21st century information, communications and entertainment services. This objective can only be realized, however, if cost effective, high-performance access solutions are deployed. DSL, delivered either directly from the central office or a fiber-fed DSLAM, continues to be the worldwide technology of choice broadband services for those operators with access to their own copper loops or, via wholesale, the copper loops of others. Dynamic Spectrum Management is a key enabling technology for deploying and operating broadband DSL services in a cost-effective manner to benefit largest possible segment of the population.